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The Keller Plan in college introductory physical geology : a comparison with the conventional teaching method

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THE KELLER PLAN IN COLLEGE INTRODUCTORY PHYSICAL GEOLOGY: A COMPARISON WITH THE CONVENTIONAL TEACHING METHOD

by

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TABLE OF CONTENTS

LIST OF TABLES

ABSTRACT

The purpose of this study is to compare the learning and attitudinal changes that took place in a college introductory physical geology class between a self paced method of instruction called the Keller Plan and the conventional lecture-laboratory method.

The sample population was 56 students enrolled in Earth Science 120, an introductory physical geology course at Minot State College during the fall quarter, 1973. An experimental section of 20 students experienced the Keller Plan treatment and two control groups consisting of 18 students each received the conventional method of instruction.

Four specific areas of investigation were tested: (1) knowledge of geology, (2) changes in attitude toward science, (3) improvement in self-concept, and (4) possible correlations between these dependent variables and a student's college class level, sex, college career plans, scholastic standing, high school size, curriculum taken in high school, and the number of science courses taken in high school.

The test instruments used are a locally prepared geology test, the Berger Acceptance of Self Scale, the Silance and Remmers Attitude Toward any School Subject Scale, and an autobiographical student background list. Data obtained from the above instruments were analyzed using computer regression analysis and the t-test.

There were no significant differences in pretest and posttest means between experimental or control groups in achievement or self-

concept. There was a significant difference in attitude toward science in the Keller Plan group (.05 level). Pretest means of the Keller Plan group were consistently lower than those of the two control groups. Achievement gains in all groups were unusually low suggesting insufficient control of the homogeneity of the groups or low validity of the geology test. When posttest-only means were compared among all three groups, no significant differences were found between experimental or control groups in achievement, attitude toward science, or self-concept. There were no significant correlations between the Keller Plan group or either control group when comparing items of student background information with achievement, attitude toward science, or self-concept.

Implications for further research are (1) additional research on the use of the Keller Plan in geology teaching, (2) development of a more adequate geology content test, (3) better randomization other than by normal registration procedures, and (4) additional controls to be added to the geology content taught in all groups.

CHAPTER I

FORMULATION AND DEFINITION OF THE PROBLEM

Introduction

Traditionally, the teaching method used in most college introductory geology courses has been the lecture-laboratory approach. The long and continued use of this method could be assumed to attest to the advantages inherent in the system. It is generally agreed by educators that the lecture method is very efficient in terms of staff requirements and the amount of material that can be presented in a short time. However, agreement cannot be found on students' enjoyment of the method, content achievement, retention, or the basic attitudes toward science and learning that students take with them after completing a lecture-lab course in geology. In summarizing research on teaching at the college and university level, McKeachie (1963, p. 1128) found that lecturing is an excellent way to communicate information, an effective competitor with the textbook, and most efficient where there are differences in student background, ability and interest. But he qualified his observations by stating:

> Because the lecture provides little feedback, does not always present material in an optimum sequence, allows the student to be passive, and provides little direct experience, lectures may be inferior to other teaching media in achieving certain goals.

During the sixties and early seventies there was a trend among college students to seek relevancy in their studies. At the same time, one of the main thrusts of education methodology during this period has been to individualize learning. This approach has taken several forms including contract teaching, the use of teaching machines, and audio-visual-tutorial methods among others. In colleges and universities this individualization of learning is identified under the general classification of Personalized System of Instruction (PSI). Although there are many manifestations of this form of instruction (PSI), one developed by Professor F. S. Keller, henceforth to be referred to as the Keller Plan, appears to have received some acceptance for college level instruction. The method of instruction proposed by this plan differs in many respects from conventional methods of lecture-lab college teaching. Among these differences are (1) the use of proctors in a preferred ratio of one per 10 students, (2) the use of keyed guides, (3) the individual plotting of readiness and performance, and (4) the requirement of demonstrated competency before progressing to new material. The value of this method of instruction has been attested to by many educators in many colleges and in many disciplines. Limited evidence of its use in teaching freshman geology courses is reflected in the literature.

Purpose

The purposes of this study are (1) to compare achievement, attitude toward science, and self-concept in a freshman physical geology course between students taught using the Keller Plan and those taught using the conventional method of instruction, and (2) to analyze any relationships that might exist between the above three variables and the following personal data of the students:

a. Curriculum program followed in high school.

b. Number of science courses taken in high school.

c. Career plans of the students.

d. Scholastic standing of the students.

3. Sex.

f. Size of the student's high school.

g. Class level of the students.

In regard to (1) and (2) above, the questions asked in the study were:

1. Would geology students who received the Keller Plan method of instruction exhibit a higher degree of content achievement than those geology students who received the conventional method of instruction?

2. Would geology students who received the Keller Plan method of instruction exhibit a more positive attitude toward science than those geology students who received the conventional method of instruction?

3. Would geology students who received the Keller Plan method of instruction exhibit a higher level of self-concept than those geology students who received the conventional method of instruction?

4. Are there any correlations between student personal data, self-concept, attitude toward science, and achievement, and whether the student was taught using the Keller Plan or the conventional method of instruction?

Significance of the Study

Today, many students are coming to college from high schools that have used contract and audio-visual-tutorial (AVT) methods. When they start college there should be viable alternate methods of instruction for them to select should their inclinations lead that way. In teacher-training-oriented colleges, the introductory geology courses may contain a high percentage of potential elementary and secondary school teachers. The remark is often made that a teacher teaches like he has been taught. It would seem prudent he should be exposed to a self-paced method such as that offered by the Keller Plan. It should also be noted that the elementary and secondary science curriculum projects such as Elementary Science Study (ESS), Science A Process Approach (SAPA), and Earth Science Curriculum Project (ESCP), that these teachers may have to use, stress the processes of science, and PSI courses in college may be of help to them in pursuit of the individualization know-how.

In addition, there are many behavioristic and humanistic characteristics embodied in PSI courses that are some times lacking in traditional teaching methods. The Keller Plan is behavioristic in that it embraces Skinnerian principles of reinforcement theory because students are rewarded at many stages of the instruction thus enhancing learning. The Keller Plan is humanistic because the student is controlling the rate at which he learns and how he goes about it. Besides, the personal interaction of student, tutor, and teacher appears to offer a better environment for learning to take place. These characteristics can lead to possible significant changes in the attitudes of the learner toward science and toward learning itself. Many students believe that they can never do well in science and their self-concepts and attitudes are adversely affected. Emergence from the introductory geology courses with more positive attitudes and self-concepts can be of lasting value to the student.

Definition of Terms

For the purpose of this paper the following definitions are set out to avoid possible confusion with any other usage.

Achievement. Achievement is a term used to indicate the degree of mastery of the subject matter of an academic discipline.

Attitude Toward Science. This phrase indicates the like or dislike, or positive or negative feelings that a person has about the subject of science.

Self-concept. Self-concept refers to the attitudes and beliefs that a person holds about himself.

Science Background. This term refers to the science courses of biology, physics and chemistry that a student has taken in high school.

High School Curriculum. This relates to the course of study taken by a student in high school, operationalized as General, Business, or College Preparatory.

Scholastic Standing. This term is defined as a student's opinion of where he thinks he stands in relation to others, that is, the upper one-third of the class, middle one-third of the class, or lower one-third of the class.

Keller Plan. This is a method of college instruction as defined by Fred S. Keller, being primarily self-paced and tutorial.

School Size. High schools (grades 9 through 12) with enrollments of up to 250 students are defined as being small whereas those of enrollments over 250 students are considered to be in the large category.

Class Level. Class level is defined as the student's credit hour standing, thus being designated by the college as a freshman, sophomore, junior or senior.

Limitations of the Study

The limitations of the study are as follows:

1. The sample population was 56 students, 20 in an experimental section, and 18 in each of two control sections.
2. The period of the study was 12 weeks (one college quarter).
3. There was normal attrition of students between pre- and post-tests.
4. Sections met at different times of day as prescribed by the college schedules.
5. Randomization of the students to the three sections was only that as provided by the regular registration procedures of Minot State College on registration days.
6. All teachers used the same topic outline.
7. All students had access to the same laboratory materials.
8. Three different instructors were utilized.

CHAPTER II

REVIEW OF RELATED LITERATURE

General Historical Background

The Keller Plan began in 1964, when Fred S. Keller and several associates at the University of Brazilia experimented with a system of instruction variously described as self-paced, proctorial and personalized. Primarily in use at the college level, the Keller Plan of instruction encompasses the basic ideas of intrinsic motivation and the reinforcement principles of the type described by Skinner (1968), who espoused a guided experience kind of instruction using the behavioristic theories of stimulus-response methodologies. A brief account of the Keller method is given in Appendix A. Keller (1968, p. 83) summarized five basic features of the plan that distinguish it from a conventional method of teaching:

1. The go-at-your-own pace feature which permits a student to move through the course at a speed commensurate with his ability and other demands upon his time.
2. The unit-perfection requirement for advance which lets the student go ahead to new material only after demonstrating mastery of that which preceded.
3. The use of lectures and demonstrations as vehicles of motivation, rather than sources of critical information.
4. The use of proctors, which permits repeated testing, immediate scoring, almost unavoidable tutoring, and a marked enhancement of the personal social aspect of the educational process.

During the 1960s other authors in the educational field were writing of humanizing and personalizing the school environment, emphasizing the inner needs and feelings of the student. Rogers (1965) popularized the idea that students should be responsible for their own learning. In science, a teaching method, helping students learn and test theories and develop confidence in their own roles and attitudes, is generally referred to as the discovery method. Bruner (1961) attributed an increase in a learner's intellectual power and enjoyment of learning for its own sake to the discovery method.

The Personalized System of Instruction Newsletter, published by the Psychology Department of Georgetown University, has become a clearing house of information for the use of the Keller Plan or very similar self-paced individualized methods of instruction in the nation's colleges and universities. In the October 1971 issue, the PSI Newsletter reported on a nationwide survey and, of 500 responses from college instructors, 250 indicated that they were using a PSI format in their courses. The disciplines of physics, chemistry, biology, astronomy, and mathematics were included in that number. By June of 1972, in a more detailed survey according to specific disciplines, the Newsletter reported college-level PSI instruction as shown in Table 1.

In a Keller Plan seminar held at the Massachusetts Institute of Technology (MIT) in June 1972, of the 75 participants, only one person in addition to myself indicated that his disciplinary field was geology. That same summer, a National Science Foundation Institute (July 1972) on the Keller Plan attracted 20 participants, none of whom listed their discipline as geology.

A poll taken in October 1973 and reported in the Newsletter (June 1974) indicated that a total of 410 instructors were now using a PSI format (Table 2). Geology was not represented. By April 1974,

TABLE 1

NUMBER OF COLLEGE INSTRUCTORS USING A PSI FORMAT (1972)[a]

Discipline	Number	Discipline	Number
Psychology	73	Spanish	4
Physics	38	Computer Programming	4
Engineering	21	Sociology	3
Mathematics	20	Office Management	1
Chemistry	15	Speech Communication	1
Biology	6		
English	4	Total	190

[a]PSI Newsletter June 1972.

TABLE 2

NUMBER OF COLLEGE INSTRUCTORS USING A PSI FORMAT (1974)[a]

Discipline	Number	Discipline	Number
Psychology	157	Sociology	16
Physics	53	English	11
Engineering	49	Economics	6
Mathematics	49	Geography	6
Chemistry	31	Computer Science	11
Biology	21	Total	410

[a]PSI Newsletter June 1974.

when a national conference on personalized instruction in higher education convened in Washington, D. C., a total of 780 participants attended (PSI Newsletter 1974a). For the first time mention was made of the involvement of earth science. It is not known whether this reference included any instructors from the field of college geology. Also in June 1974, a seminar was held for college teachers of Keller-PSI courses at the University of Texas at Austin.. Of the 168 participants, I was the only one who indicated a major field of geology. Thus, although the Keller Plan is readily adaptable for teaching a wide variety of college subjects, prior to 1974 it has seen very limited use in the teaching of geology courses.

Use of the Keller Plan in Geology Teaching

In early reports of reactions with the Keller Plan, writers reported on mostly the qualitative aspects of the method utilizing student comments in anecdotal form. Because there was a scarcity of reports on the use of the Keller Plan in geology, I made inquiry to the Educational Research Center (ERC) at MIT. ERC has been active in promoting the use of the Keller Plan in college teaching. Green (1971) communicated to me that as of that date, only two courses were known to him in which Keller Plan techniques were utilized. The first was that of an earth science course entitled Evolution of the Earth at MIT taught by Richard Naylor. Naylor (1972) indicated that he was indeed happy with the results of using the Keller Plan since 1971, but that no specific data had yet been collected. Naylor (1974, p. 139) has since published a more detailed account of his five years experience with the Keller Plan in historical geology. His stated purpose was:

" . . . to remind geologists of the existence of this technique [Keller-Plan] and to provide practical how-to-do-it suggestions. . . ." The other course was in use at St. Petersburgh Jr. College, Florida. Mott (1972) commented that he had used a modification of the Keller Plan in his earth science course, but that the course relied more extensively on the audio-tutorial approach to learning as developed and practiced by S. N. Postlewait of Purdue University.

In the fall of 1972, at Minot State College, at the beginning of a course in physical geology, I asked two sections of students to complete a questionnaire that attempted to measure their attitudes toward strict, highly structured school practices. The instrument was one adapted from Mitchell's Attitude Toward Education Scale (Shaw and Wright, 1967). The results were as follows: (1) 62 per cent favored less strict, less structured school practices, (2) 25 per cent favored strict, more structured school practices, and (3) 13 per cent indicated neutral attitudes toward school practices. The implication was that a Keller Plan type of format would be acceptable to a majority of the students. These two sections then became part of a pilot program to assess the merits of the Keller Plan in geology teaching and to serve as a forerunner of the investigation of this paper. One section, termed the experimental group (N=31), was taught using the Keller Plan and the other, the control group (N=14), was taught using the traditional lecture-laboratory method. I served as the instructor in both sections. At the conclusion of the course, the experimental group was administered Hand's Scale to Study Attitudes Toward College Courses (Shaw and Wright, 1967), adapted specifically to study attitude toward method. Eighty-three per cent indicated strongly positive reactions to the method used, whereas 17 per cent indicated only mildly positive or neutral attitudes. Additionally, a 70-question multiple-choice final examination (Appendix B) was given to both groups. A t-test indicated that the difference between the means of the posttest scores for each group was not significant.

As a part of this pilot plan, an attempt was made to assess faculty reaction to the plan. When the pilot plan was in progress, five other geology instructors observed and questioned different facets of the method. No other instructor has since chosen to conduct a Keller Plan course. However, one of the physics instructors liked what he saw and instituted the Keller Plan in one of his introductory physics courses. But after one quarter, he discontinued use of it and has not tried it again. Thus, while staff reaction was mixed, student reaction was favorable and students readily took responsibility for their own learning. I concluded that the Keller Plan was a viable alternative to the traditional method of presenting introductory physical geology (Walsh, 1973a).

In order to further assess faculty attitude toward the Keller Plan, a questionnaire incorporating over 100 items was sent to 94 science and mathematics teachers throughout the nation who had indicated they were using or intended to use the Keller Plan in their courses. In a summary of the results of 44 returned replies, Walsh (1973b) reported that 35 would definitely use the Keller Plan again. The summary of other questionnaire responses is included in Appendix C.

Use of the Keller Plan in Disciplines Other Than Geology

When comparing traditional teaching of college physics, chemistry, biology, and geology, it is found that there is a very similar format employed. Usually three lectures and one or two laboratory sessions each week is the rule. The Keller Plan has been little used so far in geology teaching, and much experience has been gained with using the Keller Plan in other science areas. It, therefore, seems reasonable to explore the results of using the Keller Plan in science disciplines other than geology.

Many of the aspects of the audio-tutorial approach to teaching, at the discretion of the instructor, are often incorporated into the study guides of the Keller Plan, particularly in regard to viewing slides or filmloops or listening to associated audio tapes. Postlethwait, Novak, and Murray (1972, p. 131) defined this method as:

> . . . a programming of a sequence of study activities in the voice of the senior instructor. In contrast to other media, the student has control of the rate at which he proceeds with his study, an opportunity to replay as often as he desires, but most importantly, all of the conventional experience involving the handling of specimens, doing experiments, manipulating the microscope and other items of this nature are retained.

Grobe (1972) examined achievement between students in an audio-tutorial versus a conventional biology course and concluded that there was no significant difference (.05 level) in the achievement between the two groups.

The Keller Plan is essentially mastery-learning to the extent prescribed by the objectives. Block (1973, p. 34) in a comprehensive look at mastery learning wrote:

> At least in the short run, mastery approaches to learning can yield greater student interest in and more positive attitudes toward the topic learned than can non-mastery approaches, although if students are asked to master a subject too well, this may turn them off. Mastery approaches can also generate in students increased confidence in their ability to learn. Finally, students

> really enjoy learning by mastery approaches. . . . Last but not least, mastery approaches to learning have yielded some evidence, primarily anecdotal and impressionistic, that they are learning students how to learn.

Moore, Mahan, and Ritts (1969, p. 891) made three replications of an experiment with biology, philosophy, and psychology students using a continuous progress (mastery) approach. Specifically looking at increase in achievement and student attitude toward instructional process, they found that the performance of the students in the experimental group was higher and their attitudes toward the instructional procedure more favorable than the control group. They concluded:

> . . . as data from all three disciplines on all dependent variables were in the same direction, it seems reasonable to suggest that the effectiveness of the procedures employed may be relatively independent of the academic discipline involved and the appropriateness of the "mastery concept" is not limited to a particular discipline.

In an investigation with 95 college students enrolled in a physical science course for elementary education majors, Magnus (1973) studied self-directed instruction and teacher-directed instruction. Students in an experimental group (self-directed) did not perform any better than students in a control group (teacher-directed). However, at a much later post-test date, he found that the experimental group did retain the content material better than the control group. Also in the same study, he detected no significant difference in student attitudes toward physical science between either group.

Phillips and Sommerfeldt (1972, p. 1305), working with 100 students in an experimental Keller Plan section and 100 students in a traditional control section in a non-calculus physics course, reported that although initial costs were high and that students accepted the

Keller Plan enthusiastically, the level of achievement in the two sections did not differ significantly. In their discussion they made this observation:

> Suppose we had all been educated under the system of instruction called the Keller Plan and had subsequently upon entering the teaching profession continued to use it in our courses. Imagine that the current experiment was done to evaluate a new system of instruction called the "lecture." Our findings would indicate that however hard we worked on the lecture system, it was no more effective than the old and tried Keller system.

After using the Keller Plan in biology for one year at Lowell State College, Protopapas (1971, p. 2) compared the final examination scores and the final grades earned of a lecture and a Keller Plan section (Table 3). In a somewhat more subjective evaluation, he added:

TABLE 3

GRADE DISTRIBUTION (FINAL EXAMINATION AND FINAL COURSE GRADE) OF A BIOLOGY CLASS AT LOWELL STATE COLLEGE (1971)[a]

	Final Examination Grade (%)					
Grade	A	B	C	D	F	
Keller Plan	20	40	40			
Lecture Section	4	16	41	16	16	
	Final Course Grade (%)					
Grade	A	B	C	D	F	I
Keller Plan	34.4	50	12.5			
Lecture Section	5.4	23.8	41	21.8	7	1

[a]From Protopapas 1971.

> My own feeling is that the Keller Plan course was a complete success. I have always enjoyed lecturing and have received positive feedback from the students. However, I am sure that the students learned more and derived greater personal satisfaction from the self-paced course.

As noted earlier in this chapter, distribution of the disciplines using the Keller Plan method shows that psychology leads the list. Possibly this is because Keller himself was a psychologist, but much has been written about the use of the Keller Plan in college psychology courses. Several investigations have demonstrated that the Keller Plan produces greater mastery of content material than the traditional lecture type format. McMichael and Cory (1969, p. 80), in reporting about a study of 880 students in an introductory psychology class, said:

> The mean [final exam] score out of 50 possible points for each of the groups was: Control A, 35; Control B, 34; Control C, 34; Experimental [Keller group], 40. An analysis of variance showed the overall effect to be highly significant ($F=35.5$, $df=3, 764$; $p<0.005$). Post hoc t-tests revealed that the most substantial differences among groups existed between the experimental group and each of the control groups ($p<0.0001$ for each comparison). By contrast, the differences among the control groups were slight, with none reaching the 0.01 level of significance in spite of the large number of subjects.

Also, student ratings of the course revealed that the experimental group rated the course higher than did the control groups. Hess (1971), in discussing implementation problems when using the Keller Plan, compared final examination scores in a traditional lecture section with a Keller Plan section of a general psychology course and found that 86 per cent of the students in the Keller section scored above 80 per cent and 83 per cent of the students in the traditional version scored below 70 per cent. Utilizing 301 students, Sheppard and MacDermot (1970), in a somewhat similar psychology course, found that on a 100-question final examination, the mean score for the experimental (Keller Plan) group was 73.1 ($s=12.1$) and the mean score for the control group was 66.8 ($s=11.9$). A t-test showed that the difference between the means was significant beyond the .01 level.

Keller (1968), in his oft-quoted discussion of his techniques, pointed out that an oddity of his system was that it invariably produces an inverted grade distribution from what would normally be expected in his traditional type courses. That is, there is a large percentage of A and B grades with very few C, D, and F grades. And since the course is divided into many small units and mastery (90 or 100 per cent) is required on each unit, he inferred that this method does produce an equal or greater amount of content achievement.

The Keller Plan has been used successfully in the fields of applied engineering and mathematics. Hoberock, Koen, Roth and Wagner (1971) evaluated the plan for use in nuclear engineering, mechanical engineering, electrical engineering, and applied statistics and concluded that the students (94, 82, 94 and 77 per cent) found the learning experience more pleasurable than in conventional courses and learned more than in conventional courses. Based on student and staff evaluation of a proctorial system course in statistics, Wagner and Motazed (1971, p. 50) stated that their results support other research findings that a proctorial system of instruction is successful and that a learning system has been developed for applied statistics which "results in a more thorough and deeper understanding of the material with longer retention." In this same study, 80 per cent of the students felt they had a deeper knowledge of the material using the proctorial approach over the conventional lecture approach. Koen (1971, p. 27) said this regarding the use of the Keller Plan in engineering education:

> The students in this class have exhibited a characteristically positive reaction towards the course, the nuclear engineering content, the professor, and education in general. They look

> forward to taking the exams since the threat of failure no longer hangs over them. One student was moved to say, "It is ironical that I learn how to learn as a senior just when I'm about to graduate."

Not all reports on the Keller Plan are favorable nor is the Keller Plan adaptable to every teaching situation. While using the method in astronomy, Dessler (1971, p. 12) concluded:

> The Keller method is probably best applied to the more elementary courses in which some definite knowledge or specific skill is to be taught. . . . The Keller method of instruction can no more be replaced by written material than a lecturer can be replaced by a movie projector or tape recorder. . . . The conventional lecture method which has reached its present state of refinement after centuries of evolution, is certainly not in any danger of losing its prime position. The Keller method will for many years to come be a useful adjunct to the lecture method.

Mattuch (1972, p. 6), a professor of mathematics at MIT interviewed in the school magazine The Tech, observed:

> Self pacing can distort the emphasis of the course [3rd level calculus] badly. . . . In a self-paced course the exams are everything and it is virtually impossible to lecture on anything but straight exam material. In other words, the general culture aspect of the course . . . could be lost.

In a study of an individualized Keller-type course in arithmetic at a community college, Dahlke (1972) found that this kind of course failed the more poorly prepared students. Success in the course was related to the number of semesters of high school mathematics courses taken, and pre-course achievement in computation and application.

Self-Concept and Attitude

The literature on self-concept is very extensive. Psychological research has developed persuasive arguments that relate school achievement directly to one's concept of self. Purkey (1970, p. 2), after a thorough review of self-concept, stated that: "Many of the difficulties which people experience in the areas of life are closely connected with the ways they see themselves and the world in which they live." He also believed that the evidence strongly supports the case that far too many students have experienced difficulty in school not due to poor eyesight, poverty, or low intelligence, but because they see themselves as incapable of taking on academic work. In reviewing studies on the relationship of the self and academic performance, Purkey (1970, p. 22) observed:

> The available information on the non-achiever suggests that he holds unflattering views about himself . . . and it seems reasonable to assume that unsuccessful students whether under-achievers, non-achievers, or poor readers, are likely to hold attitudes towards themselves and their abilities which are pervasively negative.

A large part of a student's life is spent attending school and if the Keller Plan, which shows promise in improving attitudes and self-concepts, is a good method of instruction, then it should be utilized wherever appropriate.

Researchers seem to be in almost unanimous agreement that most students appear to have more positive feelings about Keller Plan courses than typical lecture-laboratory courses. Mager (1968, p. 10) suggested:

> If one of our goals is to influence the student to think about, learn about, talk about, and do something about our subject some time after our direct influence over him comes to an end, how can we say we have been successful if the student actively avoids any further mention of the subject? Whatever else we do in the way of influencing the student, the least we must strive to achieve is to send him away with favorable rather than unfavorable feelings about the subject or activity we teach. This might well be our minimum and universal goal in teaching.

The terms "self-actualization" and "fully functioning self" are utilized by psychologists in attempting to define the kind of person who is achieving to the utmost of his ability. Combs (1965, p. 14) declared that highly adequate personalities tend to see themselves in essentially positive ways, and in discussing perceptual psychology, he observed:

> Of all the perceptions existing for an individual none are so important as those he has about himself. . . . In adulthood people may suffer from feelings of being unable to make a speech, dance or do arithmetic. . . . The effect of the self-concept extends far beyond the matter of skills. . . . We now know that even an individual's adjustment or maladjustment is likely to depend on the ways in which he perceives himself.

In working with the Keller Plan, students are provided with specific objectives or goals for each unit of work. A former Miss America and now a motivation specialist, Marilyn Van Derbur (1974, p. 70), in teaching a mini-course to students in grades 7-12 in the Denver and Phoenix schools, wrote that her most important class was one in which the importance of having goals and a way to achieve these goals was discussed. She added, "I believe that helping students with their goals aids them in building a positive self-image."

Brookover and Thomas (1964), in testing over 100 seventh grade students in self-concept, found that there was a significant and positive correlation between self-concept and how they performed academically. In addition, they found that there were specific self-concepts of ability related to specific academic role performance and that these were different from the general self-concept of ability. In other words, they were referring to a hypothesis that self-concepts related to arithmetic, English, social studies and science would be different from the general self-concept of ability. In males, the specific concept of ability was higher in mathematics and science. For females, the correlation was high in social studies. Another aspect of the study indicated that "significant others" (mother, father, teacher, peers) contribute heavily to an individual's self-concept of ability. In the Keller Plan, the "significant others" would primarily be peers and teacher, but to a greater extent the student's proctor.

In reviewing the literature pertaining to discrepant achievement Taylor (1964, p. 74) determined that underachievers usually lack confidence in themselves besides having a poor conception of their scholastic performance. He found: "The underachiever is self-derogatory and depressed in attitudes, has feelings of inadequacy, concern about health, and poor overall adjustment, while the overachiever is optimistic, self-confident and holds a high opinion of himself." The weight of the evidence in the psychological literature has also led him to make these conclusions (p. 80):

1. The degree to which a student is able to handle his anxiety is directly related to his level of achievement.
2. The value the student places upon his own worth affects his academic achievement.
3. Students who are accepted and have positive relationships with peers are better able to accept themselves.
4. The more realistic the goal the more chance there is of successful completion of that goal.

There seems to be little doubt that self-concept and school achievement are positively correlated. Dyson (1967, p. 405) studied the topic of ability grouping and self-concept in seventh grade populations. The high achievers reported significantly more positive academic self-concept, whereas self-concept for low achievers was found to be significantly less positive. Dyson noted that success in school influences academic self-concept regardless of the grouping procedures used. He concluded:

> The research reported here lends emphasis to the importance of success or failure in school in the determination of self-attitudes. It would appear that many factors must contribute positively, each in its own way to a comfortable psychological climate in which boys and girls can feel secure as individuals, and experience personal progress.

The way a course is taught can have a bearing on an individual's self-concept and PSI courses are geared to reward the student for progress in his quest for the goals of the unit and the course.

One of the features of the Keller Plan is that of not being penalized should one fail to pass a readiness test. The chance is there to take additional tests, without penalty, in order to show competency in a unit of work. This results in less test anxiety and students often take as many as 20 or 30 tests in a semester's or quarter's work without complaint. Test anxiety can have a dramatic effect on one's self-concept. Kowitz (1971, p. 163), in investigating this problem, reported that test anxiety "occurs as a major destructional force when the student perceives the evaluation as a vicious assault upon his self-concept." He found that when the evaluation of pupil achievement was separated from the evaluation of the student himself as a person, "the unknown threat, the basis for test anxiety, is gone."

Many other authorities have reported a positive correlation between self-concept and achievement. It was a thesis of this study that the Keller Plan method of teaching contained elements of learning such that the attitudes of students toward the subject matter of science and thus their attitudes toward learning itself would change positively. Rogers (1968, p. 2) referred to this kind of learning as "experiential learning" and observed that it is a "self-initiated learning in which the student takes hold of something for himself . . .

and which is pervasive, making a difference in his behavior, and perhaps in his attitudes and personality as well."

It was hypothesized in my study that the Keller Plan could initiate more positive self-concepts and thus lead to higher achievement. However, Hereford (1974, p. 5), in assessing the relations between student characteristics and the effectiveness of PSI, remarked:

> Experience has made it clear that certain students are simply unable to function adequately in a PSI learning environment. On the basis of our preliminary analysis, it appears that the critical factors are not intellectual. We have found, for example, that there is no difference in measured academic aptitude between students who drop or fail to complete PSI courses and those who complete them successfully. Given an adequate level of intellectual ability to cope with college level learning experiences, an individual's response to PSI appears to be related to attitudinal and personality variables such as autonomy, the need for interpersonal competition, the need for affiliation, and motivation to earn high grades. Various aspects of a student's background and current lifestyle may also influence his response to Keller Plan courses.

A review of the literature on the Keller Plan generally seems to support the conclusions of Fred Keller as presented earlier in this chapter. After three years of evaluating Keller Plan courses under a Sloan Foundation grant at the University of Texas at Austin, Stice (1975, p. 4) stated:

> Achievement measures were compared between 11 PSI courses and associated control courses. Students in PSI courses did significantly better in five of the courses, there was no difference between the two groups in five courses, and the control class did better than the PSI class in one instance. Thus ten of the eleven classes did as well or better under PSI than under conventional teaching methods.

Kulik, Kulik, and Carmichael (1974) reported searching the literature for papers that specifically tested examination performance between the Keller Plan and conventional classes. Fifteen were found and of this number, 10 investigators reported that the PSI-

Keller group performed significantly better than the conventional group and five reported no difference in performance between experimental and control groups.

Evaluated research on the Keller Plan, however, presents several areas of difficulty. Hereford (1974, p. 2) concluded:

> The evaluative approach in which PSI [Keller Plan] courses are compared with the more conventionally taught courses in terms of student achievement and attitudinal response serves to establish and ensure the credibility of the method and, for this reason, should not be abandoned. Local comparisons [at the University of Texas at Austin] of student achievement in PSI courses and courses taught by more conventional methods have indicated equal or greater student achievement in PSI courses. The major methodological problem encountered in studying relative student achievement is the use of final examination scores as the criterion variable. It cannot be validly assumed that equivalent motivational sets exist in PSI and regular classes with regard to the final examination. Frequently, the importance of a final examination in terms of contributions to course grade is quite different in PSI and control sections. Furthermore, the general set which has been created with regard to testing in the PSI section would be expected to differ markedly from that in the conventionally taught section. In addition, differing instructor standards for scoring final examinations may yield spurious results. Despite the difficulties involved, more comparisons of substantive learning under PSI and more conventional teaching methods are important.

3

CHAPTER III

DESIGN AND PROCEDURES

Design of the Study

The basic design of this study is the pretest-posttest control group design as described by Campbell and Stanley (1965). Three groups of students were used in the study. The group that received the Keller Plan treatment was designated as the experimental group. Two other groups that received the conventional method of instruction were designated as control group A and control group B. I taught the experimental group, and two other staff geology teachers instructed the control groups. All three instructors agreed on a minimal course outline by subject area (Appendix D). The study was conducted during the fall quarter 1973 at Minot State College.

Research Instruments

Three research instruments were utilized. These sought to measure self-concept, attitude toward science, and content achievement. In addition, students were asked to fill out an autobiographical information form (Appendix E).

Self-Concept Test

The instrument used to measure self-concept was the Acceptance of Self Scale developed by Emanual M. Berger of the University of Minnesota. Shaw and Wright (1967, p. 433) observed: "This is the most carefully developed scale to measure attitude toward self that we have found in the lieerature. Evidence of validity is more extensive than for most scales in this book." They also report reliability coefficients of .894 or better and a correlation coefficient of .897 for validity. The test consisted of 36 Likert-type items.

Attitude Toward Science Test

The Attitude Toward Any School Subject Scale was developed by E. B. Silance and H. H. Remmers of Purdue University. It consists of a 45-item Thurston-type scale. Shaw and Wright (1967, p. 294) reported the scale as being "reasonably valid and reliable." They indicated that the scale has equivalent-form reliabilities that range from .81 to .90, and adequate content validity as evidenced by the studies of several researchers.

Content Test

A survey of standardized content tests for physical geology was conducted utilizing the reference manual of Buros (1972). No appropriate test instrument could be found. Therefore, a local test instrument was constructed. Five copies of multiple-choice examinations were chosen from among those on file in the Earth Science Department at Minot State College. These were tests that had been given to physical geology students repeatedly over the past five or six years. From these tests, the three instructors chose 35 questions (Appendix F), and checked each answer against the course of study outline as previously mentioned under the design section of this chapter. By means of the Item Analysis and Scoring (TESTAT) Computer Program (1973), using achievement scores from the students involved in the study, a reliability coefficient of .72 was determined for the pretest, and .65 for the posttest.

Administration of the Test Instruments

The three test instruments and the one autobiographical information sheet mentioned previously, were administered to all groups as a pretest. This was accomplished during the first laboratory class period of each section. Mr. Myron Dammen from the counseling and guidance section of the Student Personnel Services Division of Minot State College supervised the pretest sessions. The language of his instructions was identical for each group. All testing was conducted in the same large earth science laboratory room. At the conclusion of the course, posttests were administered during the last laboratory session for each group. The same forms of the instruments were used and similar testing procedures were used except that each instructor supervised the final posttesting sessions. Six students were not on hand for the posttest. They were contacted and appeared the following day for testing.

Sample Population

The 56 students in this investigation were enrolled in three of five sections of Earth Science 120, an introductory physical geology course offered at Minot State College. The Keller Plan group contained 16 freshman students compared to zero in control group A and seven in control group B. Conversely, control group A contained 11 sophomore students, and control group B ten, compared to only three in the Keller Plan group. A profile of these students by characteristic and number in each section is shown in Table 4. The high school size of a student was obtained from the records of the registrar. The assignment of

TABLE 4

STUDENT PROFILE INFORMATION BY CHARACTERISTIC

Section	Class Level				Sex		Science Courses in H.S.		College Career Plans		Scholastic Standing[a]			Curriculum Taken in H.S.[b]				Size of H.S.	
	Fr.	So.	Jr.	Sr.	M	F	1	>1	4 yr	Other	L	M	U	B	C	G	O	Large	Small[c]
Keller Plan Group	16	3	1	0	6	14	12	8	16	4	2	13	5	3	7	9	1	9	11
Control Group A	0	11	3	4	11	7	7	11	18	0	0	8	10	5	3	10	0	11	7
Control Group B	7	10	0	1	11	7	7	11	15	3	2	12	4	2	5	11	0	9	9

[a]L = Lower 1/3, M = Middle 1/3, U = Upper 1/3

[b]B = Business, C = College Preparatory, G = General, O = Other

[c]Large = more than 250 students; Small = up to 250 students

students to any particular section was accomplished through the regular registration procedures of the college. Some degree of randomization was present as students chose a particular section depending upon the time schedules of other courses or as the geology course would best fit their schedule. Registration was held on two consecutive days with senior, junior, and sophomore registering on the first day, and freshmen registering on the second day.

The experimental section (N=20) to which the Keller Plan treatment was applied, was assigned to meet for six hours per week from 1:00 to 3:00 P.M. on Monday, Wednesday, and Friday. Laboratory materials were available during this time. There was no separate laboratory period. Control group A (N=18) met for lecture at 9:00 A.M. each Monday, Wednesday, and Friday, and control group B (N=18) met at 2:00 P.M. the same days of the week. One two-hour per week laboratory session was provided for each control section, with control group A assigned from 8:00 to 10:00 A.M., and control group B assigned from 1:00 to 3:00 P.M., both on Thursday.

Method of Instruction

The Keller Plan Method

This plan differs from other methods of instruction in that it utilizes proctors (tutors), who work with a group of students in a preferred ratio of one tutor to 10 students. The tutors are selected by the instructor and are usually undergraduate majors, but could also be graduate teaching assistants or even peer tutors. In this investigation three undergraduate majors were used as tutors.

The class first viewed a short color slide presentation on the Keller Plan that I had previously formulated during two other pilot programs in which the Keller Plan was used. Each student was then given the first lesson guide. This guide contained specific behavioral objectives, sample questions, procedures, and other pertinent information about the unit under study. It also provided the student with an overview and format of the Keller Plan method of instruction. The student was asked to purchase the text Physical Geology by Leet and Judson (1971) and the Physical Geology Laboratory Manual by Hamblin and Howard (1971), to be used as reference material. The unit guides were keyed to this set of texts.

The student also received a chart that graphed the number of units completed versus the time of the school quarter. He could plot his progress and know at any time whether he was ahead or behind schedule, or on an average, satisfactory pace. A copy of this chart was also kept in the student's file folder. These folders, in turn were kept in a locked file cabinet with guide sheets and unit tests. Each tutor had a personal key to the cabinet, as did I.

When a student felt that he was ready for a unit test, he obtained one from his tutor and went to a specified part of the room to take the test. There were three and sometimes four, alternate forms of the test for each unit, and each test included about ten questions. The type of question varied and included multiple-choice, short answer, completion, and sometimes, depending upon the unit, asked the student to demonstrate some manual proficiency. For example, the student might be asked to demonstrate or read the dip and strike of a simulated sedimentary rock layer using the Brunton compass. The student's tutor graded the test immediately and if the student passed, he was allowed to start on the next unit. Ninety per cent correct response was considered as acceptable to demonstrate competence. If he did not pass, he could be quizzed orally by the tutor in the event that parts of his answers were unclear. If competency was still not obtained, he was not penalized as he could take additional tests as necessary during the next class period or when he thought he was again ready.

The course was held in a large (40 x 200 feet) geology, laboratory-type classroom. Students also had the option of using an adjacent, empty classroom for study and, if and when a lesson guide suggested viewing film loops, specimens, or specific reading reference material, a small AVT room equipped with carrels, projectors, tape deck, and other equipment, was available on the floor below. Tutors and the instructor were always on hand in the main laboratory room during regularly assigned class hours. Laboratory materials were made available at these times and, whenever possible, were left out so that they could be used at any time of the day or evening until 10:00 P.M., except on Saturday and Sunday. No lectures were scheduled as such, but movie film and slides were shown at various intervals to the group as announced previously on the student's bulletin board. Roll was not taken. Final grades were determined by the number of units successfully completed, that is, 14 = A, 12 = B, and 10 = C.

The Conventional Method

The two control groups met three times each week for 50 minutes in a traditional lecture setting. One group used an auditorium and the other used a large lecture classroom. One 2-hour period per week was provided for a laboratory exercise in the same room as used by the experimental group. No restrictions were placed on either control group instructor. Each was free to teach as his training and personality dictated, except that neither teacher used any self-paced or Keller Plan format. Grades were assigned on the basis of a midterm and final examination. This mode of instruction conformed to the lecture-laboratory method in general use at Minot State College for this type of class.

Statistical Treatment

Score responses and data collected from the administration of the four test instruments were transferred to IBM coding sheets for keypunching on standard IBM punch cards. Calculations were done by personnel of the University of North Dakota Computer Center using an IBM Model 370/135 data processor. Two programs were used. The Related T-Test (RELT) Program (1973) computed and printed out the t-values, means of the differences, standard deviations and errors of the differences between each set of the two related means of the self-concept, attitude, and content variables for the pre-post tests. Second, the Multiple Linear Regression (STWMULT) Program (1973) utilized the post-test scores of the same three variables to compute means and standard deviations, correlation coefficients between each of the independent and dependent variables, t-values, and F-values for the analysis of variance of the multiple regression, plus other data normally supplied by this program. In this program, group membership was used as the predictor variable and the scores served as the criterion variable. Several of the autobiogrphical variables were binary coded, that is, "1" was recorded if the characteristic was present, or "0" was recorded if the characteristic was absent (Williams, 1974).

CHAPTER IV

ANALYSIS OF THE DATA

Hypotheses

The null hypotheses of the study were as follows:

1. There is no significant difference in the means of the posttest scores in achievement between students taught using the Keller Plan and those taught using traditional methods of instruction.
2. There is no significant difference in the means of the posttest scores in attitude toward science between students taught using the Keller Plan and those using traditional methods of instruction.
3. There is no significant difference in the means of the posttest scores in self-concept between students taught using the Keller Plan and those taught using traditional methods of instruction.
4. There is no significant difference in the means of the pretest-posttest scores in achievement between students taught using the Keller Plan and those taught using traditional methods of instruction.
5. There is no significant difference in the means of the pretest-posttest scores in attitude toward science

between students taught using the Keller Plan and those taught using conventional methods of instruction.

6. There is no significant difference in the means of the pre-test posttest scores in self-concept between students using the Keller Plan and those using conventional methods of instruction.

7. There is no significant correlation between achievement and eight items of personal student background information when comparing students taught using the Keller Plan and those taught using traditional methods of instruction.

8. There is no significant correlation between attitude toward science and eight items of personal student background information when comparing students taught using the Keller Plan and those taught using traditional methods of instruction.

9. There is no significant correlation between self-concept and eight items of personal student background information when comparing students taught using the Keller Plan and those taught using traditional methods of instruction.

The presentation of data in Chapter IV follows the same order as the presentation of the null hypotheses above. The hypotheses were tested utilizing the pretest and posttest data administered to the students during the course of the project. Also the personal background information provided by the students was used in this analysis.

Null hypotheses 1, 2, and 3

The posttest data on achievement, attitude toward science, and self-concept was evaluated using a linear regression approach. Group membership in the experimental or control group was used as the predictor variable and achievement, attitude toward science, and self-concept as criterion variables. The results of this analysis are shown in Tables 5, 6, and 7.

TABLE 5

ONE-WAY ANALYSIS OF VARIANCE OF POSTTEST SCORES IN ACHIEVEMENT

Source	df	Sum of Squares	Mean Squares	F[a]
Treatment	2	15.25	7.63	0.29
Error	53	1403.59	26.48	
Total	55	1418.84		

[a]An F-value of 3.18 is required for significance at .05 level.

TABLE 6

ONE-WAY ANALYSIS OF VARIANCE OF POSTTEST SCORES ON ATTITUDE TOWARD SCIENCE

Source	df	Sum of Squares	Mean Squares	F[a]
Treatment	2	0.22	0.11	0.30
Error	53	20.02	0.38	
Total	55	20.24		

[a]An F-value of 3.18 is required for significance at .05 level.

TABLE 7

ONE-WAY ANALYSIS OF VARIANCE OF POSTTEST SCORES OF SELF-CONCEPT

Source	df	Sum of Squares	Mean Squares	F[a]
Treatment	2	56.35	28.18	0.08
Error	53	18919.00	356.96	
Total	55	18975.35		

[a]An F-value of 3.18 is required for significance at .05 level.

Since no significance was indicated in any of the above three tables, the membership in the groups could not be considered as a predictor of the criterion variables. Therefore, null hypotheses 1, 2, and 3 were accepted.

Null Hypothesis 4

A student's t-test was applied to the pretest and posttest scores on achievement between the experimental and control groups. The results are shown in Table 8. As expected, content knowledge gain occurred with both methods in all three sections. At first inspection there appears to be a higher level of significance in achievement among those students using the Keller Plan. However, the pretest mean of this group was substantially lower than the means of the two control groups. In addition, the posttest means of all three groups are unusually low. It could reasonably be expected that these means should be many points higher. Normally, on the strength of the t-ratio alone, hypothesis 4 would be rejected. However, in view of the above observations, this hypothesis was accepted. Elaborating comments are made in the discussion section of Chapter V.

TABLE 8

PRETEST-POSTTEST EXPERIMENTAL TO CONTROL SCORES IN ACHIEVEMENT

Group	Pretest Mean	SD	Posttest Mean	SD	t-ratio
Keller Plan	11.30	4.59	14.30	5.05	3.43[a]
Control A	13.39	4.54	15.06	5.10	2.28[b]
Control B	13.00	3.61	15.56	5.29	2.32[b]

[a]Significant at the .01 level.

[b]Significant at the .05 level.

Null Hypothesis 5

A student's t-test was applied to the pretest and posttest attitude toward science scores. The results as well as means and standard deviations are shown in Table 9. The data showed significance at the .05 level for those using the Keller Plan and therefore null hypothesis 5 was rejected.

Null Hypothesis 6

The pretest and posttest data provided by the scores on self-concept were evaluated by the student's t-test and no significant change in the student self-concept was found between the experimental and control groups. Therefore, hypothesis 6 was accepted. The results are recorded in Table 10.

TABLE 9

PRETEST POSTTEST EXPERIMENTAL TO CONTROL SCORES OF ATTITUDE TOWARD SCIENCE

Group	Pretest Mean	SD	Posttest Mean	SD	t-ratio
Keller Plan	7.76	0.99	8.24	0.32	2.56[a]
Control A	8.10	0.94	8.24	0.67	0.71
Control B	8.24	0.47	8.10	0.78	0.72

[a]Significant at the .05 level.

TABLE 10

PRETEST-POSTTEST EXPERIMENTAL TO CONTROL SCORES OF SELF-CONCEPT

Group	Pretest Mean	SD	Posttest Mean	SD	t-ratio
Keller Plan	136.70	12.89	139.55	14.65	1.19
Control A	138.61	24.52	141.72	23.05	1.04
Control B	140.94	19.42	141.56	18.48	0.26

In Tables 8, 9, and 10, the pretest means for the Keller Plan group are consistently lower than for the two control groups.

Null Hypotheses 7, 8, and 9

A regression program was used to obtain possible correlations between achievement, attitude toward science, self-concept, and eight student background characteristics. The correlations are reported for each variable against the predictors of student background and are shown in Tables 11, 12, and 13. No significant correlation was found between any of the student background variables and the dependent variables of achievement, attitude toward science, and self-concept.

TABLE 11

CORRELATIONS BETWEEN ACHIEVEMENT AND STUDENT BACKGROUND VARIABLES (N=56)

Source (Predictors)	r	Significance[a]
Class Level	0.20	NS
Sex	-0.13	NS
Number of Science Courses Taken in High School	0.12	NS
Career Plans	0.14	NS
Rank Standing--Upper 1/3rd	0.19	NS
Rank Standing--Middle 1/3rd	-0.12	NS
Curriculum Taken in High School	-0.02	NS
Size of School	0.15	NS

[a]NS=Not significant. An r-value of 0.27 is required for significance at the .05 level.

TABLE 12

CORRELATIONS BETWEEN ATTITUDE TOWARD SCIENCE AND STUDENT BACKGROUND VARIABLES (N=56)

Source (Predictors)	r	Significance[a]
Class Level	0.14	NS
Sex	-0.04	NS
Number of Science Courses Taken in High School	0.01	NS
Career Plans	0.04	NS
Rank Standing--Upper 1/3rd	0.06	NS
Rank Standing--Middle 1/3rd	-0.12	NS
Curriculum Taken in High School	-0.04	NS
Size of School	-0.20	NS

[a]NS=Not significant. An r-value of 0.27 is needed for significance at the .05 level.

TABLE 13

CORRELATIONS BETWEEN SELF-CONCEPT AND STUDENT BACKGROUND VARIABLES (N=56)

Source (Predictors)	r	Significance[a]
Class	0.25	NS
Sex	0.12	NS
Number of Science Courses Taken in High School	-0.08	NS
Career Plans	-0.03	NS
Rank Standing--Upper 1/3rd	0.11	NS
Rank Standing--Middle 1/3rd	-0.14	NS
Curriculum Taken in High School	-0.266	NS
School Size	-0.09	NS

[a]NS=Not significant. An r-value of 0.27 is needed for significance at the .05 level.

The program also computed an analysis of variance comparing the student background variables with the criterion variables of achievement, attitude toward science, and self-concept. The results of this are shown in Tables 14, 15, and 16. No significant F-values were indicated. Hypotheses 7, 8, and 9 were accepted.

TABLE 14

ONE-WAY ANALYSIS OF VARIANCE OF STUDENT BACKGROUND VARIABLES AND ACHIEVEMENT CRITERION

Source	df	Sum of Squares	Mean Squares	F[a]
Treatment	8	162.24	20.20	0.76
Error	47	1256.60	26.74	
Total	55	1418.84		

[a]An F-value of 2.14 is required for significance at the .05 level.

TABLE 15

ONE-WAY ANALYSIS OF VARIANCE OF STUDENT BACKGROUND VARIABLES AND ATTITUDE TOWARD SCIENCE CRITERION

Source	df	Sum of Squares	Mean Squares	F[a]
Treatment	8	2.07	0.26	0.67
Error	47	18.17	0.39	
Total	55	20.24		

[a]An F-value of 2.14 is required for significance at the .05 level.

TABLE 16

ONE-WAY ANALYSIS OF VARIANCE OF STUDENT BACKGROUND VARIABLES AND SELF-CONCEPT CRITERION

Source	df	Sum of Squares	Mean Squares	F[a]
Treatment	8	2988.62	373.58	1.10
Error	47	15986.74	340.14	
Total	55	18975.36		

[a]An F-value of 2.14 is required for significance at the .05 level.

CHAPTER V

DISCUSSION, SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Discussion

The results of the study relating to attitude toward science and self-concept are self evident, but discussion of the achievement criterion is in order.

It was hypothesized that there would be no difference in the degree of final achievement between students taught using the Keller Plan and those taught using conventional teaching methods. By first using a regression approach, an analysis of variance indicated that there was no significant difference in the final posttest achievement score means among any of the groups and this hypothesis was sustained. When the pretest-posttest means were analyzed by t-test, the results showed that, as expected, significant learning gains did take place for all three of the groups with the Keller Plan group showing a higher degree of significance in these gains. However, as previously noted in Chapter IV, the pretest mean for the Keller group was substantially lower than either pretest mean of the control groups. It can be theorized that this could have resulted from the fact that the Keller group contained more freshman students and fewer students of higher class rank than either control group. Also, control group students had more high school science subjects than those of the Keller Plan group.

Inspection of the posttest means from all three groups indicate only a two to three point gain over the pretest mean scores. Normal gain expectations should be greater than this since a theoretical mean of over twice that amount was possible. This observation leads me to question any apparent higher achievement gain for the Keller Plan group.

No specific reason can be cited for this apparent lack of higher posttest mean scores. In retrospect however, two hypotheses can be postulated. First, posttest examination scores were not used by the instructors to figure final grade averages (Appendix G) of the students, and it is possible that students did not take as much care in answering posttest questions. In fact, final examinations had already been given in the control groups before the students were asked to complete the posttest test battery. In the case of the Keller Plan group, no final examination was required. Second, adequate controls were not built in the design to assure that all of the prescribed subject material was covered by each instructor. Therefore, the locally constructed content test may not have tested what it was designed to cover.

Because of these circumstances the original investigation hypothesis of no difference in final achievement within the groups on the basis of pretest-posttest data must also be sustained.

Summary

The purpose of this study was to compare learning and attitudinal changes that took place in a college introductory physical geology class between a self-paced method of instruction known as the Keller Plan and that of the conventional lecture-laboratory teaching method.

The following areas were tested: (1) knowledge of geology, (2) changes in attitude toward science, (3) improvement in self-concept, and (4) possible correlations between the above and a student's college class level, sex, college career plans, scholastic standing, high school size, curriculum taken in high school, and the number of science courses taken in high school.

The research sample consisted of 56 college students enrolled in three sections of an introductory physical geology course during the fall quarter 1973 at Minot State College. The experimental section of 20 students was taught using the Keller Plan and two control sections of 18 students each were taught using the traditional lecture-laboratory type of instruction.

Students were given pretests and posttests using a test battery consisting of the Berger Acceptance of Self Scale, the Silance and Remmers Attitude Toward Any School Subject Scale, and a locally designed physical geology achievement scale. Data obtained from these instruments, together with student data from a personal information form were analyzed statistically using t-test and regression analysis.

Conclusions

Achievement

An analysis of variance of posttest score means in achievement showed that neither the Keller Plan group nor either of the control groups differed significantly from each other. Pretest to posttest learning gains were noted in all groups, but no conclusive evidence was shown to indicate that the experimental Keller group performed any better than either of the control groups in the cognitive area of geology content.

No significant correlation was noted between eight student background variables and the criterion of achievement.

Attitude Toward Science

A comparison of the posttest means from each group revealed no significant differences in final scores because of membership in any particular group. However, when pretest to posttest means were analyzed by t-test, the Keller Plan group means showed a significant change whereas the control groups did not.

Student background variables did not show any significant correlations with the attitude toward science criterion.

Self-concept

An analysis of variance of posttest score means on self-concept showed that neither the Keller Plan group nor either of the control groups differed significantly from each other. Pretest to posttest changes in self-concept were not significant for any of the three groups.

No significant correlation was noted between eight student background variables and the criterion of self-concept.

Recommendations

One of the main premises of this study was that if achievement levels in Keller Plan groups are equal to or better than conventional modes of instruction, then this method is one that can be used in introductory geology teaching more than it has been up to the present time. This study did not confirm this premise, but a majority of reports on the use of the Keller Plan, as evidenced by the references cited in Chapter II of this study, do show equal or better achievement levels than do conventional methods. However, these reports usually relate to fields other than geology. So, it is important that studies such as this one be replicated and that research continue into the application of the Keller Plan to geology teaching.

In an earlier part of this chapter, I made reference to some post-study concerns about the use and design of the locally-made geology content test. It is, therefore, also recommended that efforts be made by other researchers to develop a better instrument to measure achievement of content material at the introductory physical geology level.

Future studies should be concerned with obtaining a better randomization than is provided by college registration procedures, and in adding controls on the actual content material taught in the sections. Also, comparisons of the retention of geologic information and knowledge between Keller and control groups would be worthy of attention.

APPENDIX A

BRIEF ACCOUNT OF THE KELLER PLAN METHOD

A BRIEF DESCRIPTION OF THE KELLER PLAN[a]

Self-paced study, also called the Keller Plan or the "personalized system of instruction," is a method of organizing a course developed by psychologist Fred Keller and others. In a Keller plan course the student works at his own pace with self-study materials. He may finish a semester's work in as little as five weeks or as much as 20 weeks without prejudice to his grade. Mastery of each topic is the single criterion of progress to the next topic. Undergraduate tutors provide individual help when needed and grade achievement tests for each topic on the spot. The Keller Plan format provides personal attention to students (10 students per tutor) at an economical student-faculty ratio (100 students per faculty member). The professor sets the goals of the course, assembles the materials, writes the examinations, supervises the tutors, and gives an occasional lecture to provide the example of a professional at work and to reward students who have advanced far enjoy to enjoy it.

The material for a Keller Plan course is divided into short study units. Each unit is the subject of a brief "study guide" which carefully specifies what the student is expected to be able to do. In mastering these objectives the student may have a choice of activities, such as reading a portion of text, solving exercises, viewing films, using a computer, and performing a demonstration or take-home experiment (although this wide choice is not an essential feature of the system). When the student thinks he has mastered the prescribed material for the unit he comes to "class" at one of the scheduled hours and takes a brief examination that is graded "pass" or "no pass" on the spot and in writing by his student tutor. If he passes, the student goes on to the next unit of study; if he does not pass, he must restudy the material of the same unit until he can pass a different test on the unit. Since mastery of the material is required, student performance is improved (resulting typically in a larger fraction of A grades) compared with that in regular lecture-recitation courses. The instructor trains and supervises tutors and reviews the tests they have graded, thus assuring appropriate standards for the course.

In our experience the instructor who writes his own study guides spends somewhat more time running a Keller Plan course the first year than he probably would spend giving already-prepared lectures on the same material. We expect to reduce this time by making use of study guides adapted from those tried by others. In the second and subsequent years the Keller Plan course takes less instructor time than conventional courses. By and large, instructors who have used the Keller Plan are enthusiastic about the results. So are the students. One proof of student enthusiasm is that 75 to 90 percent of those who graduate from a Keller Plan course choose the Keller Plan option for a later course if it is available.

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[a]From M.I.T. Education Research Center

APPENDIX B

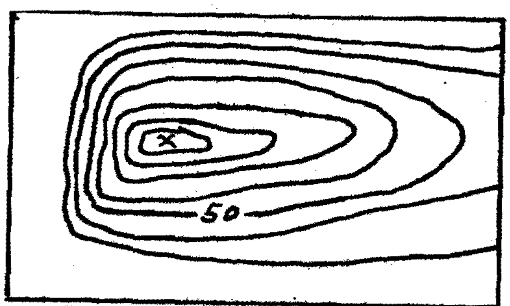
POSTTEST FOR KELLER PLAN PILOT STUDY

Final Exam for ES 120 Please mark your answers on the enclosed answer sheet by an X over the correct answer.

Questions 1 thru 8 refer to Topographic Maps

1. Refer to Fig. A. Which side is the steepest?
   a. north
   b. south
   c. east
   d. west

2. What is the elevation of point X in the same diagram?
   a. 50 feet
   b. 60 feet
   c. 70 feet
   d. 80 feet
   e. 90 feet



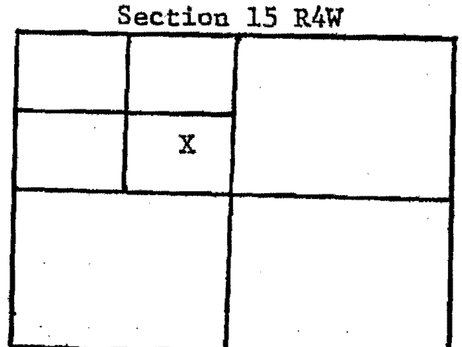
Contour Interval 10 Ft.
Fig. A

3. What statement is true about contour lines?
   a. Contour lines always branch when they cross valleys.
   b. In a valley, contour lines bend and form a V which points downstream.
   c. Contour lines are vertical lines.
   d. Contour lines cross each other at specific points.
   e. Contour lines eventually close.

4. How many sections are there in a township?
   a. 12
   b. 24
   c. 36
   d. 48
   e. 72

5. In Figure B, the location of X in Sec. 15 is:
   a. NW¼ of SW¼ T3n R4W
   b. SW¼ of NW¼ T3N R4W
   c. NW¼ of NW¼ T3N R4W
   d. SE¼ of NW¼ T3N R4W
   e. NE¼ of NW¼ T3N R4W

Section 15 R4W



T3N

Fig. B

6. A ratio map scale of 1 : 24,000 means that:
   a. one centimeter on the map is equal to 24,000 centimeters on the ground.
   b. one inch on the map is equal to 24,000 feet on the ground.
   c. one foot on the map is equal to 24,000 inches on the map.
   d. one mile on the ground is equal to 24,000 inches on the map.
   e. none of the above.

7. What is meant by a 15 minute quadrangle?
   a. The quadrangle takes 15 minutes to cross on foot.
   b. The quadrangle represents 15 thousand feet altitude at its highest point.
   c. The quadrangle covers 15 inches on the map for every 15 miles on the ground.
   d. The quadrangle represents 15 minutes of latitude and 15 minutes of longitude.
   e. The quadrangle costs 15 cents each if bought in dozen quantities.

8. The maximum latitude found in the southern hemisphere is:
   a. 45 degrees   c. 75 degrees   e. 180 degrees
   b. 60 degrees   d. 90 degrees

9. The term Bergshrund refers to a:
   a. Zone of accumulation of a glacier.
   b. Large cirque glacier.
   c. Series of glacial grooves found on rocks.
   d. Large crevasse between the glacier and headwall of the cirque.
   e. Large hanging trough formed by differential ice erosion rates.

10. The Pleistocene Epoch lasted about:
    a. one million years   c. 50 million years   e. 650 million years
    b. ten million years   d. 100 million years

11. The term <u>tarn</u>, means:
    a. a glacial stream   c. a U shaped valley   e. none of the above
    b. a glacial trough   d. a steep sided fiord

12. You would properly associate glacial plunking with:
    a. drumlins
    b. roche moutence

Use the following answers to questions 13-18
   a. tells single direction of ice motion
   b. tells either of two directions of ice motion
   c. no significance with regard to direction of ice motion

13. A drumlin

14. Striation on bedrock

15. Striation on an erratic

16. A boulder train

17. A roche moutence

18. Pater Noster Lakes

19. A till deposit along the side of a glacial valley would probably be a:
    a. kame terrace
    b. lateral moraine

20. An isolated length of linear stream deposits formed in or under the ice is preserved. It would be a(an):
    a. kame
    b. esker
    c. end moraine
    d. medial moraine
    e. terminal moraine

21. A moraine would be a:
    a. drift deposit
    b. stratified deposit

22. An indirect effect of glaciation might well be:
    a. a rise in the sea level throughout the world
    b. the formation of mountains in areas of glacial flow
    c. the introduction of pluvial climates and lakes
    d. the initiation of volcanic eruptions throughout the world

23. Which mineral would you <u>not</u> expect to find in a granite?
    a. Quartz
    b. Potassium feldspar
    c. Biotite
    d. Olivine
    e. Hornblende

24. Which mineral has cubic (Isometric) cleavage:
    a. Calcite
    b. Biotite
    e. Gypsum
    d. Muscovite
    e. Halite

25. Which is NOT a characteristic of a mineral?
    a. It is composed of one or more elements.
    b. It is formed only through organic processes.
    c. It is native if it is composed of only one element.
    d. It will always have a MOH hardness of between 0 and 10.
    e. It has a definite atomic arrangement.

26. A mineral/rock that will NOT fizz when treated with dilute hydrochloric acid is:
    a. fossiliferus limestone
    b. coquina
    c. quartz
    d. marble
    e. calcite

27. The color of the powdered mineral is referred to as its:
    a. luster
    b. diaphaneity
    c. tenacity
    d. streak
    e. specific gravity

28. A mineral which leaves a red brown steak is:
    a. magnetite
    b. hematite
    c. galena
    d. chalcopyrite
    e. pyrite

29. The mineral crystal system that has two equal axes and a third either longer or shorter, all at right angles is called:
    a. isometric c. orthohombic e. hexagonal
    b. tetragonal d. monoclinic

30. SiO_2 would be the chemical formula for:
    a. calcite c. quartz e. galena
    b. halite d. fluorite

31. An intrusive body of igneous rock of approximately uniform thickness, and relatively thin compared with its lateral extent, which has been emplaced parallel to the bedding of the intruded rocks is a:
    a. discordant pluton c. composite volcano e. sill
    b. dike d. stock

32. The funnel-shaped depression at the summit of a volcano. The bottom of the funnel opens into the channel or pipe through which the erupted material finds its way to the surface. This would be a definition of a(an):
    a. magma c. conduit e. crater
    b. lava d. pater noster lake

Indicate which of the following terms are appropriate for the statements which follow in 33-37.

33. sill a. concordant

34. stock b. discordant

35. neck c. tabular

36. batholith d. irregular

37. dike e. cylindrical

38. The Hawaiian Islands are typically formed from:
    a. composite volcanoes c. pyroclastic debris e. concordant plutons
    b. fiery Clouds d. shield volcanoes

39. What geologic event or geologic characteristic is implied if a granite body is found exposed at the surface?
    a. It would be expected to have cooled rapidly and have a glassy texture.
    b. It would be expected to contain ripple marks due to its former position under the ocean.
    c. It would be expected to show signs of both block and ropy type lava.
    d. It would indicate that large scale erosion had taken place.
    e. It would indicate that elastic rebound has taken place.

40. A type of igneous rock texture in which the crystals are large enough to be visible with the naked eye is called:
    a. phaneritic   c. aphanitic   e. smooth
    b. foiliated   d. pyroclastic

41. The most extensive lava flows in the United States are found in:
    a. New Hampshire and Vermont   c. Washington and Idaho
    b. Hawaii and California   d. Montana and Wyoming
    e. New Jersey and Connecticut

42. Which is not a texture related to sedimentary rocks?
    a. clastic   c. crystalline   e. skeletal
    b. gneissic   d. oolitic

43. The Wentworth scale would be useful in working with:
    a. sedimentary grain sizes   c. igneous rock texture
    b. sedimentary structures   d. metamorphic rock composition
    e. sedimentary rock composition

44. A rock that can be considered to be a chemical precipitate is:
    a. granite   c. schist   e. greywacke
    b. limestone   d. shale

45. The process of exfoliation:
    a. has fromed Half Dome in Yellowstone National Park.
    b. may result from unloading of overburden (Material lying over the rock).
    c. is restricted to polar regions.
    d. is produced by chemical reactions within the rock.
    e. is the result of root action.

46. A good approximation of the rate of erosion is approximately:
    a. 6cm/100 years   c. 600cm/1000 years   e. 1/6th cm/1000 years
    b. 60cm/100 years   d. 6cm/1000 years

47. A Pedocal has an accumulation of_____in its B horizon.
    a. iron   c. sodium   e. silicates
    b. calcium carbonate   d. potassium

48. You would expect a Breccia to contain:
    a. rounded fragments   c. pumice   e. blocky lava
    b. angular fragments   d. semi precious gems

49. In a mature area one expects:
    a. extreme development of flood plains   d. oxbow lakes
    b. meander belts   e. poorly define divides
    c. waterfalls and rapids

50. Mass Wasting.
    a. is a movement of material under the direct influence of gravity
    b. is aided by oversteepening
    c. may occur at a very rapid rate
    d. may be an extremely slow process
    e. all of the above

51. Which is not common of mudflows?
    a. They are typically associated with heavy rains.
    b. They involve the sliding of bedrock.
    c. They are common in desert regions where vegetation is sparce.
    d. They are a slow phenomenon.

52. Slump
    a. is a slow mass movement.
    b. involves rotation.
    c. is common at the foot of a high mountain region.
    d. is typically an accumulation of rock fragments.

53. Rejuvenation could be caused by:
    a. raising of sea level.
    b. raising of base level.
    c. increased rainfall.
    d. lowering of moisture content
    e. uplifting of an area.

54. The most abundant sedimentary rock is
    a. shale
    b. sandstone
    c. limestone
    d. arkose
    e. lignite

Questions 55-56 pertain to Fig. C

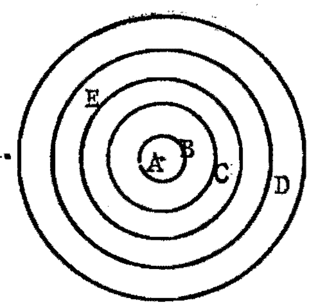


Fig. C

55. In this cross section of the earth, Zone A
    a. is probably molten.
    b. is the inner core.
    c. is the entire core.
    d. is the mantle.

56. An earthquake is pinpointed at E.
    a. This is the focus.
    b. This is the epicenter.

57. P waves are:
    a. surface waves
    b. principal waves
    c. interior waves
    d. psunami waves

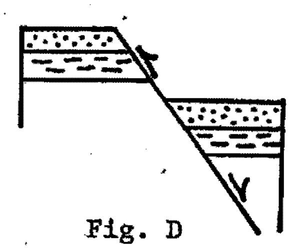


Fig. D

58. The end result of a humid cycle of erosion is:
    a. pediplain
    b. monadnock
    c. inselberg
    d. floodplain
    e. peneplain

59. The formations near the center of an eroded anticline:
    a. are older away from the center.
    b. are younger away from the center.

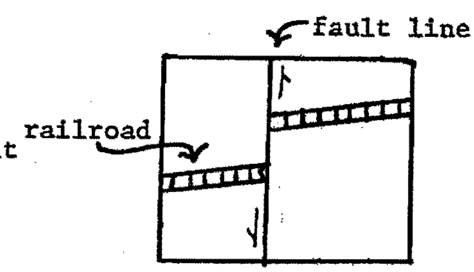


Fig. E

60. Identify the structure shown in Fig. D.
    a. normal fault
    b. reverse fault
    c. overthrust fault

61. Identify the structure shown in Fig. E.
    a. gravity fault
    b. strike-slip fault
    c. anticline
    d. syncline

62. The theory of Continental drift was first expounded by
    a. Louis Agassiz   c. Alfred Wegener   e. Albert Richter
    b. James Hutton   d. James Forrell

63. Identify the type of unconformity from Fig. F.
    a. disconformity   c. nonconformity
    b. angular unconformity

64. The theory of Plate Tectonics could possibly account for all of the above except:
    a. earthquakes   c. continental drift   e. glaciation
    b. volcanoes   d. sea floor spreading

65. Erosion is:
    a. the same as weathering.
    b. the passive process whereas weathering is an active one.
    c. largely dependent on moving water, ice, or air.
    d. limited to the last 100,000,000 of the Earth's history.
    e. a chemical process.

66. An example of a depositional landform is a (an):
    a. mesa   c. valley   e. cirque
    b. alluvial fan   d. roche moutanee

67. An example of an erosional landform is a (an):
    a. esker   c. moraine   e. arete
    b. outwash plain   d. drumlin

68. A laterite soil is most likely to be found in:
    a. Quebec   c. Minnesota   e. Canal Zone
    b. Arizona   d. Kentucky

69. Which statement concerning ice sheets is true?
    a. The ice sheet extended south to Tennessee and the Arkansas River.
    b. The ice sheet advanced and retreated over large areas of Canada, northern United States and Europe.
    c. The ice sheet covered most of the United States.
    d. The ice sheet glaciated only the northern most part of North Dakota.

"Perhaps the most valuable result of all education is the ability to make yourself do the thing you have to do, when it ought to be done, whether you like it or not; it is the first lesson that ought to be learned; and however early a man's training begins, it is probably the last lesson that he learns thoroughly"......Huxley

APPENDIX C

SUMMARY OF SURVEY QUESTIONNAIRE REPLIES ON THE KELLER PLAN

THE SURVEY QUESTIONNAIRE

The questionnaire was sent to chemistry, physics, biology, and mathematics teachers at colleges and universities. It consisted of a 3-page, 46-question, 8 inch x 11 inch format. Included was a stamped self-addressed return envelope, a covering letter and information on the experiences with the pilot Keller Plan in introductory physical geology at Minot State College. Ninety-four questionnaires were distributed and 44 replies were received.

QUESTIONNAIRE RESPONSE SUMMARY

1. Tutors are the heart of the Keller Plan approach.

   a. Were you able to use tutors in a 1 to 10 ratio or less?

      Yes: 85% No: 15%

   b. Were your tutors majors in the appropriate field of the course taught?

      Yes: 85% No: 15%

   c. Were tutors paid from appropriated funds?

      Yes: 38% No: 46% No answer: 16%

   d. Were tutors given course credit in lieu of pay for their duties?

      Yes: 42% No: 42% No answer: 16%

   e. Were tutors selected from undergraduate members of the class?

      Yes: 38% No: 34% No answer: 28%

   f. Did you notice any friendly competition between tutors in urging students forward?

      Yes: 15% No: 53% No answer: 32%

   g. Was the dependability of tutors a problem?

      Yes: 19% No: 69% No answer: 12%

h. Were tutors rotated among the student groups?

Yes: 23% No: 69% No answer: 19%

i. Did the instructor act as a tutor?

Yes: 81% No: 4% No answer: 15%

Part time: 9%, Full time: 33%, Randomly: 48%

j. General comments on tutors by respondents:

1. Tutors generally very effective
2. Scheduling a problem
3. They learn more than anyone
4. Had difficulty persuading them not to lecture to students
5. They were very willing to give time to students
6. Most problems were due to tutors

2. Course Management. Many administrative elements may be included in this type of program.

a. Did you have a course manager?

Yes: 27% No: 69% No answer: 4%

b. Did you maintain a file folder for each student?

Yes: 81% No: 12% No answer: 7%

c. Did you use a file cabinet?

Yes: 96% No: 4%

d. Did you allow students to check out file folder of their tests for review?

Yes: 54% No: 35% No answer: 11%

e. Did you encounter any security problem with the file cabinet, filing of tests, copies, etc?

Yes: 15% No: 85%

f. Did each student have an individual progress chart of his own?

Yes: 73% No: 27%

g. Did you have a classroom wall chart of all student' progress?

Yes: 65% No: 35%

h. Did you have more than one room available?

Yes: 54% No: 38% No answer: 8%

i. What was your assigned schedule for the course?

3 - 2 hr. periods	38%
2 - 2½ hr. periods	7%
3 - 3 hr. periods	4%
4 - 1 hr. periods	12%
Other combinations	29%

j. At registration, did the students know that they were signing up for a Keller type of course?

Yes: 57% No: 38% No answer: 5%

k. Did you use lectures?

Yes: 38% No: 50% No answer: 12%

l. Did you find it necessary to hybridize the plan in any way?

Yes: 23% No: 62% No answer: 15%

m. How much preparation in terms of time was needed to get the course underway?

2 weeks: 1% 3 weeks: 15% 4 weeks: 46% over 6 weeks: 38%

n. Did you detect any passing around of answers to unit tests?

Yes: 15% No: 77% No answer: 8%

3. Evaluation. The Keller Plan users arrive at student grades by a variety of methods.

a. What was your grade policy?

1. 75% based on number of units completed, 25% exam: 42%

2. Depended on the number of units completed. No exam: 35%

3. The highest grade that could be attained by completing all units was a B. Exam had to be taken to attain an A: 38%

4. Other systems. (pass/fail, Incompletes): 15%

b. What was your final grade distribution? (Av)

Chemistry -- A 70%, B 20%, C 6%, D 3%, F 1%

Physics -- A 57%, B 20%, C 14%, D 7%, F 2%

Biology -- A 30%, B 19%, C 17%, D 16%, F 18%

c. Estimate the percentage of your students who reacted favorably to the method.

Chemistry: 90%

Physics: 68%

Biology: 66%

APPENDIX D

MINIMAL COURSE OUTLINE FOR KELLER PLAN

Fall Quarter 1973

General Outline[a] for Physical Geology

E. S. 120

(not necessarily in order of presentation)

1. Topographic Maps
   - Latitude and Longitude
   - Land Office Grid System
   - Contour lines
   - Quadrangles
   - Map scales
   - Township and range
   - Declination

2. Glaciation
   - Alpine Glaciation
   - Continental Glaciation
   - Depositional Features
   - Erosional Features

3. Geology of North Dakota
   - Physiographic Provinces
   - Local features

4. Minerals
   - Physical properties
   - Chemical properties
   - Crystal systems
   - Mineral Identification

5. Volcanism
   - Types
   - Lavas
   - Historic eruptions
   - Plutons

6. Igneous Rocks
   - Classification
   - Textures
   - Composition
   - Identification

7. Weathering and Erosion
   - Mechanical
   - Chemical
   - Rates

9. Metamorphic Rocks
   - Foliation
   - Metamorphism
   - Identification

10. Cycles of Erosion
    - Hillslope erosion
    - Rapid Movements
    - Slow Movements
    - Arid cycle
    - Humid cycle

11. Earthquakes
    - Focus
    - Epicenter
    - Richter scale
    - Causes
    - Distribution

12. Mountain Building
    - Fold mountains
    - Fault mountains
    - Hypotheses

13. Structure and Deformation of earth's crust
    - Faults
    - Folds
    - Jointing
    - Unconformity

14. Continental Drift
    - Theories
    - Sea floor spreading

15. Plate Tectonics

16. Sedimentary Rocks
    - Classification
    - Textures
    - Composition
    - Identification

[a]Minimal topics

APPENDIX E

STUDENT AUTOBIOGRAPHICAL INFORMATION FORM

Please Print

INFORMATION SHEET

1. Name: ____________________

2. Address: ____________________

3. Tel. No. ____________________

4. College Class Level (Circle one) Fr. So. Jr. Sr.

5. Sex: Male _____ Female _____

6. Age _______

7. High School Science Courses taken:

   Biology ____
   Chemistry ____
   Physics ____
   Adv. Biology ____
   Geology ____
   Other ____________

8. Father's Occupation (mother's/guardian)

   Businessman ________
   Farmer ________
   Professional ________
   Other ________

9. In High School, did you participate in:

   Sports ________
   Debate ________
   Journalism ________
   Music ________
   Drama ________
   FFA ________
   Science Club ____
   Other ____________

10. Career Plans:

   2 yrs college ____
   4 years college ____
   Undecided ________

   Major area of interest if decided

   ____

11. Scholastic Standing (Where do you think you stand?)

Upper 1/3 rd of class ________
Middle 1/3 rd of class ________
Lower 1/3 rd of class ________

12. Curriculum followed in High School:

Business ________
College Prep ________
General ________
Other ________

13. Do you come from:

Farm home ________
City home ________

14. Was the community that you lived in (if other than on farm) a:

Small size city (pop. not over 1000) ________
Medium size city (1000-5000) ________
Large size city (over 5000) ________

15. If a farm home, size of nearest city:

Small ________
Medium ________
Large ________

16. Type of instruction in High School science (check all that apply):

Lecture ________
Laboratory ________
Contract ________
Project ________
Independent Study ________
Other ________

APPENDIX F

PRETEST-POSTTEST CONTENT TEST

This is a study of some of your content knowledge in the field of geology. Some persons may have little or no background in this area. Others may have a more extensive background. This is not a test. You will not be graded. This is for research purposes only. Just do the best that you can.

On the answer sheet provided, darken in the circle of the best possible single answer.

1. Dikes:
   1. are extrusive igneous features that bake the rock under them.
   2. are of metamorphic origin.
   3. cut across pre-existing structures.
   4. are older than the rocks around them.
   5. are parallel to the layering of surrounding rocks.

2. An unconformity is:
   1. a buried igneous contact.
   2. a normal sedimentary contact.
   3. a surface of deposition.
   4. composed of the same strata.
   5. a buried surface of erosion or nondeposition.

3. Which of the following is <u>least likely</u> to be involved in the erosional cycle in an arid region?
   1. pediment
   2. bajada
   3. alluvial fan
   4. playa
   5. sink hole

4. Continental drift is supported by:
   1. the shape of the continents.
   2. sea floor spreading.
   3. ancient climatic patterns.
   4. paleomagnetism.
   5. all of the above.

5. Which of the following is the <u>least likely</u> association?
   1. halite-cleavage
   2. igneous rocks-feldspar
   3. foliation-schist
   4. granite-part of a lava flow
   5. porphyritic texture-some igneous rocks

6. Pick the inconsistent answer. Mudflows:
   1. are typically associated with heavy rains.
   2. move large boulders.
   3. involve the sliding of bedrock.
   4. are a rapid phenomenon.
   5. are common in desert areas where vegetation is scarce.

7. The doctrine of Uniformitarianism:
   1. is the philosophy that geologic forces have operated in about the same manner throughout geologic time.
   2. involves the idea that great valleys were formed in one great catastrophe.
   3. is the philosophy that the earth's surface never changes.
   4. was accepted by the great majority of geologists soon after it was proposed.
   5. holds that all geologic changes are very slow and never violent.

8. Which statement is true about contour lines?
   1. Contour lines always branch when they cross valleys.
   2. In a valley, contour lines bend and form a V which points downstream.
   3. Contour lines are vertical lines.
   4. Contour lines cross each other at specific points.
   5. Contour lines eventually close.

9. A ratio map scale of 1:24,000 means that:
   1. one inch on the map is equal to 24,000 feet on the ground.
   2. one centimeter on the map is equal to 24,000 centimeters on the ground.
   3. one foot on the map is equal to 24,000 inches on the map.
   4. one mile on the ground is equal to 24,000 inches on the map.
   5. None of the above.

10. The Pleistocene Epoch lasted about:
   1. ten million years.
   2. fifty million years.
   3. one million years.
   4. 100 million years.
   5. 650 million years.

11. An indirect effect of glaciation might well be:
   1. a rise in the sea level throughout the world.
   2. the introduction of pluvial climates and lakes.
   3. the formation of mountains in areas of glacial flow.
   4. the initiation of volcanic eruptions throughout the world.
   5. the change of igneous rocks to metamorphic rocks.

12. Which mineral would you NOT expect to find in a granite?
   1. quartz
   2. potassium feldspar
   3. biotite
   4. olivine
   5. hornblende

13. Which is NOT a characteristic of a mineral:
   1. It is composed of one or more elements.
   2. It is formed only through organic processes.
   3. It is native if it is composed of only one element.
   4. It will always have a MOH hardness of between 0 and 10.
   5. It has a definite atomic arrangement.

14. What geologic event or geologic characteristics are implied if a granite body is found exposed at the surface?
    1. It would be expected to have cooled rapidly and have a glassy texture.
    2. It would be expected to contain ripple marks due to its former position under the ocean.
    3. It would be expected to show signs of both block and ropy type lava.
    4. It would indicate that large scale erosion had taken place.
    5. It would indicate that elastic rebound has taken place.

15. In glacial geology, the term TARN means:
    1. a glacial stream.
    2. a glacial trough.
    3. a U-shaped valley.
    4. a steep sided fiord.
    5. none of the above.

16. The mineral system of crystal identification that has two equal axes and a third either longer or shorter, all at right angles is:
    1. isometric.
    2. tetragonal.
    3. orthorhombic.
    4. monoclinic.
    5. hexagonal.

17. The Hawaiian Islands are typically formed from:
    1. composite volcanoes.
    2. fiery clouds.
    3. pyroclastic debris.
    4. shield volcanoes.
    5. concordant plutons.

18. The most abundant sedimentary rock is:
    1. shale.
    2. sandstone.
    3. limestone.
    4. arkose
    5. granite.

19. An example of an erosional landform is a (an):
    1. esker.
    2. outwash plain.
    3. moraine.
    4. drumlin.
    5. arete.

20. Erosion is:
    1. the same as weathering.
    2. largely dependent on moving water, ice, and air.
    3. the passive process, whereas weathering is the active one.
    4. limited to the last 100,000,000 years of the earth's history.
    5. a chemical process.

21. An intrusive body of igneous rock of approximately uniform thickness, and relatively thin compared with its lateral extent, which has been emplaced parallel to the bedding of the surrounding rocks is:
    1. a discordant pluton.
    2. a dike.
    3. a composite volcano.
    4. a stock.
    5. a sill.

22. The thinnest section of the earth's crust is found beneath:
    1. coastal plains.
    2. desert regions.
    3. mountain regions.
    4. oceans.
    5. continents.

23. The most frequent cause of major earthquakes is:
    1. faulting.
    2. folding.
    3. landslides.
    4. submarine currents.
    5. Tsunamis.

24. Which characteristic of a material would be most useful in classifying it as either a rock or sediment?
    1. The presence of layering.
    2. A range of particle sizes.
    3. The presence of intergrown crystals.
    4. Concretation of glacial material.
    5. Lacks minerals with structure.

25. A massive sedimentary rock layer composed of uniformly small particles probably formed from the:
    1. precipitation of material from sea water.
    2. cooling of a lava flow.
    3. cooling of magma.
    4. concentration of glacial material.
    5. cooling on the surface of plutons.

26. Dip is:
    1. the axis of a fold.
    2. the angle of the declination.
    3. the angle that is formed when a syncline becomes an anticline.
    4. the angle that the inclined bed makes with the horizontal plane of the surface.
    5. the slope of a stream per unit distance.

27. In an area of karst topography, you would expect to find:
    1. sinks.
    2. limestone caves.
    3. swallow holes.
    4. disappearing streams.
    5. all of the above.

28. The last glaciers left North Dakota about:
    1. 1,000,000 years ago.
    2. 100,000 years ago.
    3. 10,000 years ago.
    4. 1,000 years ago.
    5. none of the above.

29. Absolute geologic time can be determined by:
    1. the rock record.
    2. pollen grains.
    3. temperature measurements of earths interior.
    4. paleomagnetism.
    5. uranium-lead ratios.

30. The drainage pattern in a region of several parallel hogback ridges would be:
    1. radial.
    2. trellis.
    3. insequent.
    4. dendritic.
    5. subsequent.

31. A fault whose footwall side has moved up relative to its hanging wall side is:
    1. reverse.
    2. abnormal.
    3. thrust.
    4. normal.
    5. strike-slip.

32. Most valleys have been widened by:
    1. stream erosion on the bottom of the channel.
    2. downcutting action of a stream.
    3. lateral stream erosion.
    4. the action of talus on the valley walls.
    5. the action of man in mining operations.

33. Folding:
    1. represents local crustal shortening.
    2. is produced by rupture.
    3. represents tensional action.
    4. results from glacial downwarping.
    5. is the end result of the erosional process.

34. The most abundant sedimentary rock found is:
    1. slate.
    2. shale.
    3. limestone.
    4. conglomerate.
    5. marble.

35. A stratified sinuous glacial deposit called an ESKER results from:
    1. marginal streams.
    2. collapse of kame terraces.
    3. end moraine dragged by advancing glaciers.
    4. river tunnels running under the ice.
    5. retreating glaciers.

APPENDIX G

FINAL COURSE GRADE DISTRIBUTION

FINAL COURSE GRADE DISTRIBUTION (%)

Grade	A	B	C	D	F
Experimental (Keller Plan)	60	25	15		
Control Group A	6	50	33	11	
Control Group B	11	17	56	5	11

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